Claims

[c1] An apparatus for simultaneously spatially multiplexing IR spectral information for each of a plurality of samples, comprising:
at least one IR light source;
at least one sample holder which positions the plurality of samples in an optical path;
an optically dispersive element in the optical path,
wherein an emission from the at least one IR light source interacts with each of the plurality of samples along the optical path to form a corresponding plurality of sample emissions,
said plurality of sample emissions interacting with the optically dispersive element to form a corresponding plurality of dispersed sample light beams, each of said plurality of dispersed sample light beams corresponding to a respective one of the plurality of samples; and
an IR FPA detector arranged in the optical path, said IR FPA detector having multiple pixels arranged in plural rows and columns,
wherein the IR FPA detector detects the corresponding plurality of dispersed sample light beams and provides at least one output which represents the IR spectral in-

formation for each of the plurality of samples.

[c2] The apparatus of claim 1, wherein the optically dispersive element is a diffraction grating.

[c3] The apparatus of claim 1, wherein the optically dispersive element is a prism.

[c4] The apparatus of claim 3, wherein the optically dispersive element is a Pellin-Broca prism substantially transparent to IR wavelengths.

[c5] The apparatus of claim 1, wherein the optically dispersive element is adjustable, and a range of wavelengths included in the corresponding plurality of dispersed sample light beams projected onto the IR FPA detector is determined by adjusting an angle of incidence between the emission from the IR light source and a surface of the optically dispersive element.

[c6] The apparatus of claim 1, wherein the emission from the IR light source interacts with a background reference environment arranged along the optical path to provide a background reference emission,
said background reference emission interacting with the optically dispersive element to form a dispersed background reference light beam,
wherein the IR FPA detector detects the dispersed back-

ground reference light beam.

[c7] The apparatus of claim 6, further comprising a processor which receives the at least one output and a signal representing the dispersed background reference light beam,
wherein said processor, essentially in real-time, determines compensated IR spectral information for each of the plurality of samples by compensating for the background reference environment.

[c8] The apparatus of claim 1, further comprising a first polarizer in the optical path, wherein at least one of the corresponding plurality of sample emissions passes through the first polarizer to form a first polarized sample emission.

[c9] The apparatus of claim 8, further comprising a second polarizer in the optical path, wherein at least one of the corresponding plurality of sample emissions passes through the second polarizer to form a second polarized sample emission orthogonal to the first polarized sample emission,
wherein the first and second polarized sample emissions interact with the optically dispersive element to form first and second dispersed polarized light beams,
wherein the IR FPA detector detects the first and second

dispersed polarized light beams.

[c10] The apparatus of claim 9, wherein the first polarized sample emission has a polarization perpendicular to a polarization of the second polarized sample emission.

[c11] The apparatus of claim 9, wherein the first and second dispersed polarized light beams are used to determine a molecular orientation of a polymer film.

[c12] The apparatus of claim 1, wherein the IR FPA detector detects each of the corresponding plurality of dispersed sample light beams on spatially separated areas of the IR FPA detector.

[c13] The apparatus of claim 1, wherein the IR FPA detector simultaneously detects the corresponding plurality of dispersed sample light beams.

[c14] The apparatus of claim 1, wherein the at least one output determines the IR spectral information for each of the plurality of samples at a same instant in time.

[c15] The apparatus of claim 1, wherein the IR FPA detector comprises InSb.

[c16] The apparatus of claim 1, wherein the IR FPA detector comprises MCT.

[c17] The apparatus of claim 1, wherein the IR FPA detector comprises a microbolometer.

[c18] The apparatus of claim 1, wherein the at least one output from the IR FPA detector includes a plurality of summed pixel outputs at each of a plurality of wavelengths contained in the dispersed light beam,
wherein the plurality of summed pixel outputs at one of the plurality of wavelengths improves a signal-to-noise-ratio of a signal representing an intensity of said one of the plurality of wavelengths.

[c19] The apparatus of claim 1, wherein a plurality of IR FPA detector pixel outputs corresponding to at least one of a plurality of wavelengths contained in at least one of the corresponding plurality of dispersed sample light beams are summed together to improve a signal-to-noise-ratio of a signal representing an amplitude of the at least one of a plurality of wavelengths.

[c20] The apparatus of claim 1, wherein the IR FPA detector is partitioned into multiple segments each containing a different subset of the multiple pixels,
wherein each of the corresponding plurality of dispersed light beams are projected onto an associated one of the multiple segments.

[c21] The apparatus of claim 20, wherein said each of the corresponding plurality of dispersed sample light beams are projected onto the IR FPA detector such that a row direction on the IR FPA detector is essentially aligned with a dispersion direction of said each of the corresponding plurality of dispersed sample light beams,
wherein each column of the IR FPA within each of the multiple segments corresponds to a particular wavelength of light in an associated one of the plurality of dispersed sample light beams.

[c22] The apparatus of claim 20, wherein, within at least one of the multiple segments, an output from one pixel in each of a plurality of rows are added together along one column of the FPA to improve a signal-to-noise-ratio of a signal representing an intensity of an associated wavelength of light.

[c23] The apparatus of claim 20, wherein dispersed sample light beams associated with different spatial sections of one of the plurality of samples are projected onto two or more of the multiple segments.

[c24] The apparatus of claim 20, wherein different wavelengths are represented within at least two of the multiple segments.

[c25] The apparatus of claim 24, wherein dispersed sample light beams associated with different spatial sections of one of the plurality of samples are each projected onto different ones of said at least two of the multiple segments.

[c26] The apparatus of claim 1, wherein the IR FPA detector detects light having a wavelength at least in a mid-IR band.

[c27] The apparatus of claim 1, wherein at least one of the plurality of samples includes a background target having an analyte therein,
wherein the analyte reacts to a specific type of sample to produce an IR absorption change in the background target.

[c28] The apparatus of claim 27, wherein the analyte is a bio-specific reagent reactive to one or more biohazardous materials.

[c29] The apparatus of claim 28, further comprising an audible or visual alarm, or both, which are activated when the bio-specific reagent reacts to said one or more biohazardous materials.

[c30] The apparatus of claim 1, wherein said optical path includes at least one optical fiber.

[c31] The apparatus of claim 30, wherein said optical path includes a plurality of optical fibers.

[c32] The apparatus of claim 30, wherein said at least one optical fiber is a multimode fiber.

[c33] The apparatus of claim 30, wherein said at least one optical fiber propagates light in a mid-IR band.

[c34] The apparatus of claim 1, wherein said at least one sample holder includes a plurality of sampling accessories, each of said plurality of sampling accessories positioning a different sample volume in the optical path,
wherein the apparatus simultaneously determines IR spectral information for each of the different sample volumes.

[c35] The apparatus of claim 1, wherein said at least one sample holder is configured to provide an optical path for each of the plurality of samples which is suitable for detection of an IR absorption phenomena within said optical path.

[c36] The apparatus of claim 1, further comprising a plurality of optically dispersive elements for forming a plurality of dispersed light beams each corresponding to a different sample,

wherein each of said plurality of dispersed light beams is projected onto a different spatial area on the IR FPA detector.

[c37] The apparatus of claim 1, further comprising:
a display for displaying an IR spectrograph for one or more of the plurality of samples; and
means for controlling the IR FPA detector and the display.

[c38] The apparatus of claim 37, wherein the means for controlling the IR FPA detector and the display includes a personal computer.

[c39] The apparatus of claim 1, wherein IR FPA detector further comprises an IR camera.

[c40] The apparatus of claim 1, wherein the emission from the at least one IR light source is transmitted through each of the plurality of samples along the optical path.

[c41] The apparatus of claim 1, wherein the emission from the at least one IR light source reflects from each of the plurality of samples along the optical path.

[c42] A real-time, non-interferometric apparatus using IR absorption phenomena and no moving parts during operation to simultaneously perform chemical analysis in a

plurality of sample volumes, the apparatus comprising:
a broadband light source;
at least one sampling accessory for positioning the plurality of sample volumes so that at least a portion of light emitted from the broadband light source interacts with each of the plurality of sample volumes;
adjustable means for optically dispersing the at least a portion of light interacted with each of the plurality of sample volumes to obtain a plurality of corresponding dispersed sample beams;
a two-dimensional IR detector array having a plurality of detector elements arranged in rows and columns,
optical coupling means for coupling the plurality of corresponding dispersed sample beams onto the two-dimensional IR detector array; and
processor means for controlling the two-dimensional IR detector array and providing non-interferometric chemical analysis of said plurality of samples based at least upon an IR absorption spectrum in one or more particular wavelength regions,
wherein each of the plurality of corresponding dispersed sample beams are projected on multiple rows in a different area of the two-dimensional IR detector array, and corresponding column detector elements in each of the multiple rows are added together within each different area of the two-dimensional IR detector array to deter-

mine an intensity of an IR spectral component at a particular wavelength in real time,
wherein a signal-to-noise-ratio of a signal representing the intensity of the IR spectral component at the particular wavelength is increased by adding the corresponding column detector elements in each of the multiple rows.

[c43] The apparatus of claim 42, wherein the adjustable means for optically dispersing the at least a portion of light passed through each of the one or more samples is a diffraction grating having an adjustable angle of incidence with respect to incident light projected thereon.

[c44] The apparatus of claim 42, wherein the adjustable means for optically dispersing the at least a portion of light passed through each of the one or more samples is a Pellin-Broca prism having an adjustable angle of incidence with respect to incident light projected thereon.

[c45] The apparatus of claim 42, wherein the at least a portion of light emitted from the broadband light source is transmitted through said each of the plurality of sample volumes.

[c46] The apparatus of claim 42, wherein the at least a portion of light emitted from the broadband light source is reflected from said each of the plurality of sample vol-

umes.

[c47] The apparatus of claim 42, wherein the optical coupling means includes one or more optical fibers.

[c48] The apparatus of claim 42, wherein the two-dimensional IR detector array is an InSb focal plane array.

[c49] The apparatus of claim 42, wherein the two-dimensional IR detector includes MCT.

[c50] The apparatus of claim 42, wherein the processor means is a personal computer.

[c51] A method of simultaneously determining an IR spectrum of a plurality of sample volumes using a non-interferometric apparatus capable of operating using no moving parts, the method comprising:
providing an IR source;
positioning the plurality of sample volumes in an optical path;
interacting at least a portion of an emission of the IR source with the plurality of sample volumes along the optical path to form a plurality of sample emissions;
optically dispersing the plurality of sample emissions to form a corresponding plurality of dispersed sample beams;
detecting each of the plurality of dispersed sample

beams on spatially separated areas on a focal plane array having rows and columns of pixels thereon; and

simultaneously and non-interferometrically determining the IR spectrum of each of the plurality of sample emissions by evaluating a combined output from each spatially separated area of the focal plane array,

wherein each column of pixels in one of the spatially separated areas represents a wavelength contained within an associated one of the plurality of sample emissions.

[c52] The method of claim 51, further comprising adjusting an optical dispersion of the plurality of sample emissions to control a range of wavelengths in the plurality of dispersed sample beams.

[c53] The method of claim 51, further comprising increasing a signal-to-noise-ratio by co-adding a plurality of pixel outputs in said each column of pixels in said one of the spatially separated areas.

[c54] The method of claim 51, further comprising:

simultaneously evaluating a reference spectrum of an environmental background; and

correcting the IR spectrum of each of the plurality of sample to account for the reference spectrum of the environmental background.

[c55] The method of claim 51, further comprising:
simultaneously evaluating a spectrum of the IR source; and
correcting the IR spectrum of each of the plurality of sample to account for the spectrum of the IR source.

[c56] The method of claim 55, further comprising:
simultaneously evaluating a reference spectrum of an environmental background; and
correcting the IR spectrum of each of the plurality of sample to account for the reference spectrum of the environmental background.

[c57] The method of claim 51 further comprising:
processing the IR spectrum of each of the plurality of sample emissions to identify one or more signature functional groups in the plurality of sample volumes; and
enabling an alarm if said one or more signature functional groups are found in any one of the plurality of sample emissions.

[c58] The method of claim 57 further comprising:
providing a background target having a bio-specific reagent thereon; and
reacting the bio-specific reagent with a sample volume containing said one or more signature functional groups.

[c59] A method of performing chemical analysis of the plurality of samples by determining an IR absorption spectrum of each of the plurality of samples using the apparatus of claim 42, the method comprising:
projecting at least a portion of an emission of the broadband light source onto the plurality of sample volumes;
interacting the at least a portion of an emission of the broadband light source with the plurality of sample volumes;
providing a corresponding plurality of sample emissions to an optically dispersive element;
forming a plurality of corresponding dispersed sample beams;
optically coupling the plurality of corresponding dispersed sample beams onto the two-dimensional IR detector array,
wherein each of the plurality of corresponding dispersed sample beams are projected on multiple rows in a different area of the two-dimensional IR detector array;
non-interferometrically processing, within each different area of the two-dimensional IR detector array, an output from each detector in a plurality of rows of detectors, wherein each column of detectors represents a particular wavelength within each different area;
determining the IR absorption spectrum of each of the

plurality of samples by evaluating a processed output from said each detector; and

at least partially analyzing a chemical makeup of each of the plurality of samples by comparing the processed output to one or more reference standards.

[c60] The method of claim 59, further comprising maintaining the broadband light source, the optically dispersive element, and the two-dimensional IR detector array relatively motionless at least with respect to each other at least during said steps of projecting, interacting, coupling, forming, and optically coupling.

[c61] The method of claim 59, further comprising increasing a signal-to-noise-ratio by co-adding a plurality of detector outputs in each column within said each different area.

[c62] The method of claim 59, wherein said optical coupling step includes fiber optic coupling.

[c63] The method of claim 59, wherein said projecting includes fiber optical coupling the at least a portion of the emission of the broadband light source into the plurality of sample volumes.

[c64] The method of claim 59, further comprising:

interacting the at least a portion of an emission of the

broadband light source with a bio-specific reagent in a background reference sample;
detecting an IR absorption change in the background reference sample resulting from the bio-specific reagent reacting with a biohazardous material having a specific functional group; and
enabling an alarm if the IR absorption change in the background reference sample is detected.

[c65] The method of claim 59, further comprising determining, from the IR absorption spectrum of one or more of the plurality of samples, at least one physical attribute of the one or more of the plurality of samples,
wherein the at least one physical attribute is continuously determined essentially in real-time.

[c66] The method of claim 65, wherein said determining at least one physical attribute includes determining a molecular orientation of one of the plurality of samples.

[c67] The method of claim 66, wherein said determining a molecular orientation of said one of the plurality of samples is accomplished, at least in part, by comparing two orthogonally polarized sample emissions associated with said one of the plurality of samples.

[c68] The method of claim 67, wherein said one of the plural-

ity of samples is a polymer film.

[c69] The method of claim 65, wherein said determining at least one physical attribute includes measuring a thickness of a film in real-time.

[c70] An apparatus for simultaneously collecting, processing, and displaying IR spectral information for one or more samples, comprising:
a plurality of IR light sources;
at least one optically dispersive element;
a plurality of optical paths;
an IR FPA;
processing means for processing an output of the IR focal plane array and determining the IR spectral information; and
display means for displaying the IR spectral information,
wherein each of the plurality of IR light sources presents a different angle of incidence with respect to the one or more samples,
wherein each of the plurality of optical paths directs an associated one of a plurality of reflected IR beams to a different spatial area on the IR FPA.

[c71] The apparatus of claim 70, wherein each of the plurality of IR light sources has a different intensity.

[c72] The apparatus of claim 70, wherein at least one of the plurality of optical paths includes a polarizing element.

[c73] The apparatus of claim 70, wherein at least one of the plurality of optical paths includes fiber optical coupling.

[c74] The apparatus of claim 70, wherein said processing means determines a molecular orientation of a polymer monolayer from IR spectral information determined from the different spatial areas on the IR FPA.

[c75] A method of determining anisotropic IR optical constants of a material, comprising:
providing a substrate;
projecting an IR light source onto a surface of the substrate at a non-perpendicular angle of incidence;
transmitting a first transmitted portion of the IR light source through the substrate;
coupling the first transmitted portion of the IR light source through an optical path and onto a first area on a FPA;
providing a film material on the substrate;
projecting the IR light source onto a surface of the film material at the non-perpendicular angle of incidence;
transmitting a second transmitted portion of the IR light source through the film material and the substrate;
coupling the second transmitted portion of the IR light

source through the optical path onto a second area on the FPA;
rotating a mirror in the optical path to move the second area on the FPA so as to coincide with the first area on the FPA;
determining an angle of refraction within the film material by measuring an angle of rotation of the mirror.

[c76] The method of claim 75, further comprising computing a refractive index and an absorption coefficient of the film material.

[c77] The method of claim 75, wherein said providing a substrate includes providing a dielectric substrate having known optical properties.

[c78] The method of claim 75, wherein said providing a film material on the substrate includes providing a monolayer film adsorbed on the substrate.

[c79] The method of claim 75, further comprising projecting the IR light source onto a surface of the substrate at a plurality of non-perpendicular angles of incidence; and determining the angle of refraction within the film material by measuring the angle of rotation of the mirror for each of the plurality of non-perpendicular angles of incidence.

[c80] The method of claim 75, further comprising projecting polarized IR radiation through the film material and the substrate;
determining directionally specific angles of refraction within the film material; and
computing directionally specific complex indices of refraction of the film material.

[c81] The method of claim 80, further comprising calculating an orientation of at least one molecular group in the film material.

[c82] An arrangement for measuring an orientation of a thin film on a substrate, the arrangement comprising:
an IR source;
two orthogonally polarized filters which receive an IR light beam from the IR source;
a PAIR detector; and
a processor,
wherein two orthogonally polarized IR beams emanating from the two orthogonally polarized filters are reflected from the thin film and detected by the PAIR detector,
wherein a differential reflectivity spectrum is calculated by the processor, and
wherein the differential reflectivity spectrum is substantially free of any polarization-independent signals in-

cluding water vapor absorptions, instrumental drifts, and signal fluctuations.

[c83] The arrangement of claim 82, wherein the PAIR detector includes an InSb FPA.

[c84] The arrangement of claim 82, wherein the PAIR detector includes an MCT FPA.

[c85] The arrangement of claim 82, wherein the PAIR detector includes a microbolometer FPA.

[c86] The arrangement of claim 82, wherein the processor uses the calculated differential reflectivity spectrum to determine a molecular orientation of the thin film.

[c87] A method of determining an orientation of a thin film on a substrate, the method comprising:
providing an IR source;
producing two orthogonally polarized light beams from the IR source;
reflecting the two orthogonally polarized light beams from the thin film,
detecting the two reflected orthogonally polarized light beams with a PAIR detector; and
calculating a differential reflectivity spectrum in the processor using the two reflected orthogonally polarized light beams, wherein the differential reflectivity spectrum

is essentially free of any polarization-independent signals including water vapor absorptions, instrumental drifts, and signal fluctuations.